U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

FUZES

1. OBJECTIVE

The objective of this MTP is to provide testing and evaluation procedures for determining whether artillery, mortar, and recoiless rifle ammunition fuzes meet the requirements of QMR's, SDR's, and TC's, particularly in the area of safety and reliability.

2. BACKGROUND

The fuze is a physical system containing a device(s) that predicts or senses a target and initiates the functioning of a projectile. It performs this function before, upon or shortly after impact, at a certain time interval, or by an electronic signal.

A fuze is required for almost all artillery, mortar, and recoilless rifle projectiles. When assembled to the projectile it functions as an integral part of the projectile. For the projectile to inflict the desired effects on, or damage to, a target, much depends upon fuze reliability in initiating the functioning of the projectile at the most effective time and place. For this reason it is desirable to test a fuze in conjunction with the tactical projectile(s) for which it is to be used, especially when both are undergoing engineering testing.

A fuze system usually contains one or more mechanical, electromechanical, or electronic devices for target sensing and initiation of functioning. A fuze that contains a multiple device providing an option in initiation may be set for the type of initiation desired by use of a screwdriver, by hand, or by fuze setter. Fuzes may also be designed to incorporate features that result in muzzle action, definite delay times to complete the function, delayed arming for safety, self-destruction antijamming, etc. Fuze designs usually contain at least two independent safety features activated by separate forces when possible. Usually, longitudinal and rotational accelerations are employed. The fuze generally contains the most sensitive explosives of the projectile; i.e., detonators, relays, leads, primers, and booster, combinations of which are referred to as the "explosive train."

Except for special applications, fuzes are attached to the profectile by the use of matching machined threads universal to most projectiles and fuzes. This permits interchangeability of fuzes with the various projectiles.

3. REQUIRED EQUIPMENT

Equipment required by referenced MTP's and MIL-STD's.

* Supersedes Interim Pamphlet 10-40

4. REFERENCES

A. AR 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions.
B. MIL-STD-331, Fuze and Fuze Components, Environmental and Performance Tests For.

Laboratory Tests

101 Jolt
102 Jumble
103 Forty-Foot Drop
104 Transportation Virbration
105 Temperature Humidity
106 Vacuum-Steam-Pressure
107 Salt Spray (Fog)
108 Waterproofness
109 Rain Test (Exposed Fuze Storage)
110 Fungus Resistance
111 Five-Foot Drop
112 Extreme Temperature Storage
113 Thermal Shock
114 Rough Handling (Packaged)
115 Static Detonator Safety

Field Tests

201 Jettison (Aircraft Safe Drop) (Fuzes)
202 Jettison (Simulated Aircraft Safe Firing, from Ground Launcher) (Rocket Type)
203 Jettison (Simulated Aircraft Safe Drop, from Ground Launcher)
204 Jettison (Aircraft Safe Firing) (Rocket Type)
205 Jettison (Aircraft Safe Drop) (Fuze Systems)
206 Accidental Release (Low Altitude, Hard Surface)
207 Muzzle Impact Safety (Projectile)
208 Impact Saft Distance (Projectile)
209 Missile Pull-Off from Aircraft on Arrested Landing (Ground Launcher Simulated)
210 Time to Air Burst (Projectile Time)
211 Field Parachute Drop
212 Catapult and Arrested Landing

Explosive Components Test

301 Detonator Output Measurement by Steel Dent
302 Detonator Output Measurement by Lead Disc

C. MIL-STD-810, Environmental Test Methods.
D. TM 9-1300-203, Artillery Ammunition.

E. USAMC Regulation 385-12, Safety Verification of Safety of Materiel From Development Through Testing, Production, and Supply to Disposition.
F. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
G. Information Handbook of the JANAF Fuze Committee and Working Subcommittees, compiled March 1964.
H. Information Pertaining to Fuzes, Vols. I through IV, Ammunition Engineering Directorate, Picatinny Arsenal, Dover, N.J.
I. Special Study of Setback and Spin for Artillery, Mortar, Recoilless Rifle, and Tank Ammunition, Aberdeen Proving Ground, Report DPS-2611, January 1968.
J. MTP 2-1-004, Telemetry.
K. MTP 2-2-815, Rain and Freezing Rain.
L. MTP 3-1-002, Confidence Intervals and Sample Size.
M. MTP 3-1-004, Artillery Range and Ballistic Match Firings (Indirect Fire).
N. MTP 3-2-615, Radio Frequency Radiation Hazards to Electro-explosive Devices.
O. MTP 3-2-825, Location of Impact or Air Burst Positions.
P. MTP 3-2-828, Statistical Aids.
Q. MTP 4-2-015, Close Support Rockets and Missiles.
R. MTP 4-2-501, Projectiles.
S. MTP 4-2-504, Safety Evaluation - Artillery, Mortar and Recoilless Rifle Ammunition.
T. MTP 4-2-509, Airdrop Capability of Explosive Materiel.
U. MTP 4-2-601, Drop Tower Tests for Munitions.
V. MTP 4-2-602, Rough Handling Tests.
W. MTP 4-2-804, Laboratory Vibration Tests.
X. MTP 4-2-806, Impact Sensitivity of Fuzes.
Y. MTP 4-2-807, Fuze Functioning Time - Superquick Fuzes.
Z. MTP 4-2-808, Fuze Functioning Time - Airburst Fuzes.
AA. MTP 4-2-809, High Elevation (Vertical) Firing Technique for Recovery.
AB. MTP 4-2-818, Testing for Fungus Resistance.
AC. MTP 4-2-819, Sand and Dust Testing of Ammunition.
AD. MTP 4-2-820, Humidity Tests.
AE. MTP 4-2-826, Solar Radiation Tests.
AF. MTP 4-2-829, Vertical Target Accuracy and Dispersion.
AG. MTP 6-2-508, Electromagnetic Vulnerability.

5. SCOPE

5.1 SUMMARY

This MTP outlines safety tests, supplementary environmental and and shock tests, functioning and operational tests for artillery, mortar, and recoilless rifle ammunition fuzes. Functioning and operational test methods

are presented according to the fuze characteristic that initiates functioning: impact, time, and proximity. These characteristics are described in Appendix A.

5.2 LIMITATIONS

None

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Design Review

A prerequisite for formulating an engineering test (ET) for a fuze is that testing agency become familiar with the design agency's fuze design principles, product improvement objectives when they apply, technical characteristics, and weapon systems applicable to the fuze, as well as the QMDO, QMR, SDR, MIL-STD, and other publications pertaining to fuze design and requirements.

The most important launch parameters affecting fuze performance are projectiel setback and spin. In the planning of tests, emphasis is placed on testing in weapon systems that produce conditions of maximum setback, maximum spin, minimum setback, and minimum spin. This information may be obtained from Figures 1 and 2, supplemented by Report DPS-2611 (reference 4I). Other factors to be considered are effects of firing from worn weapon tubes, propelling charges with widely different burning characteristics (as evidenced by time-pressure data), and effects of various zone charges (for zoned ammunition); similarity of weapon tube length, twist of rifling, projectile design differences with possible effects on launching and flight conditions, and other dissimilarities in the internal and external ballistics of the system.

6.1.2 Training and Familiarization of Personnel

Ensure that test personnel are trained in the operation of the test item in accordance with technical documentation available to include:

a. Safety procedures during testing
b. Safety characteristics of the test item

6.2 TEST CONDUCT

6.2.1 Safety Evaluation

The philosophy and necessity for a safety evaluation as explained in MTP 4-2-504 is applicable to fuzes. Fuze safety is of paramount importance. The fuze must not create a hazard during storage, transport,

handling, launch, or flight. The safety data may be used to supplement functioning data (paragraph 6.2.3) and vice versa if test results are satisfactory and applicable. The criteria for determining fuze safety include the following:

a. The fuze shall not function as a result of nondestructive conditioning tests performed prior to firing the round.

b. To be considered launch safe, the fuze shall not function prematurely in the bore of the weapon (except for special ammunition specifically designed to do so).

c. To be considered flight safe, a fuze shall not function in flight after safe separation and before impact with the target or, when applicable, at a specific time prior to mean flight time which is consistent with design requirements, at a rate greater than that permitted in the appropriate QMR, SDR, or product improvement plan. If no flight completion is specified, it will be assumed that the fuze must not function before reaching 90% of the predicted mean flight time.

NOTE: Some QMR's and SDR's require that the flight trajectory be considered as being comprised of three zones when judging the flight safety of a fuze. Trajectory zones near the gun and near the target, under which the probability of causing a casualty to tactically dispersed troops is P_L or greater with X% assurance, are considered a matter of safety. The mid-range under which the probability of a casualty is less than P_L is considered only as affecting reliability. Assumptions as to troop disposition and concealment and acceptable values of P_L and X are determined with the aid of USACDC.

d. During launch or flight, a fuze shall not separate nor shall components become detached to the extent that erratic flight of the projectile occurs or friendly troops are endangered.

e. Delay arming safety devices must operate within specified design limitations of the fuze.

f. If, during handling tests, the fuze or cartridge is deformed to the extent that the round cannot be fired, it shall be safe to handle and dispose of.

To achieve the desired statistical confidence in the safety of the test item would require a sample size that is uneconomically large and impractical to test. Thus, the total safety evaluation must encompass not only firing tests of reasonable proportions, but engineering judgment based upon other factors as well. The safety evaluation of fuzes which leads to a Safety Release (see MTP 4-2-504) involves the following procedures.

6.2.1.1 Preparation for Test

a. Design Review - The design of the test item is studied to determine which components have adequately proven themselves in designs of other fuzes, and which are relatively untried and deserving of more attention.

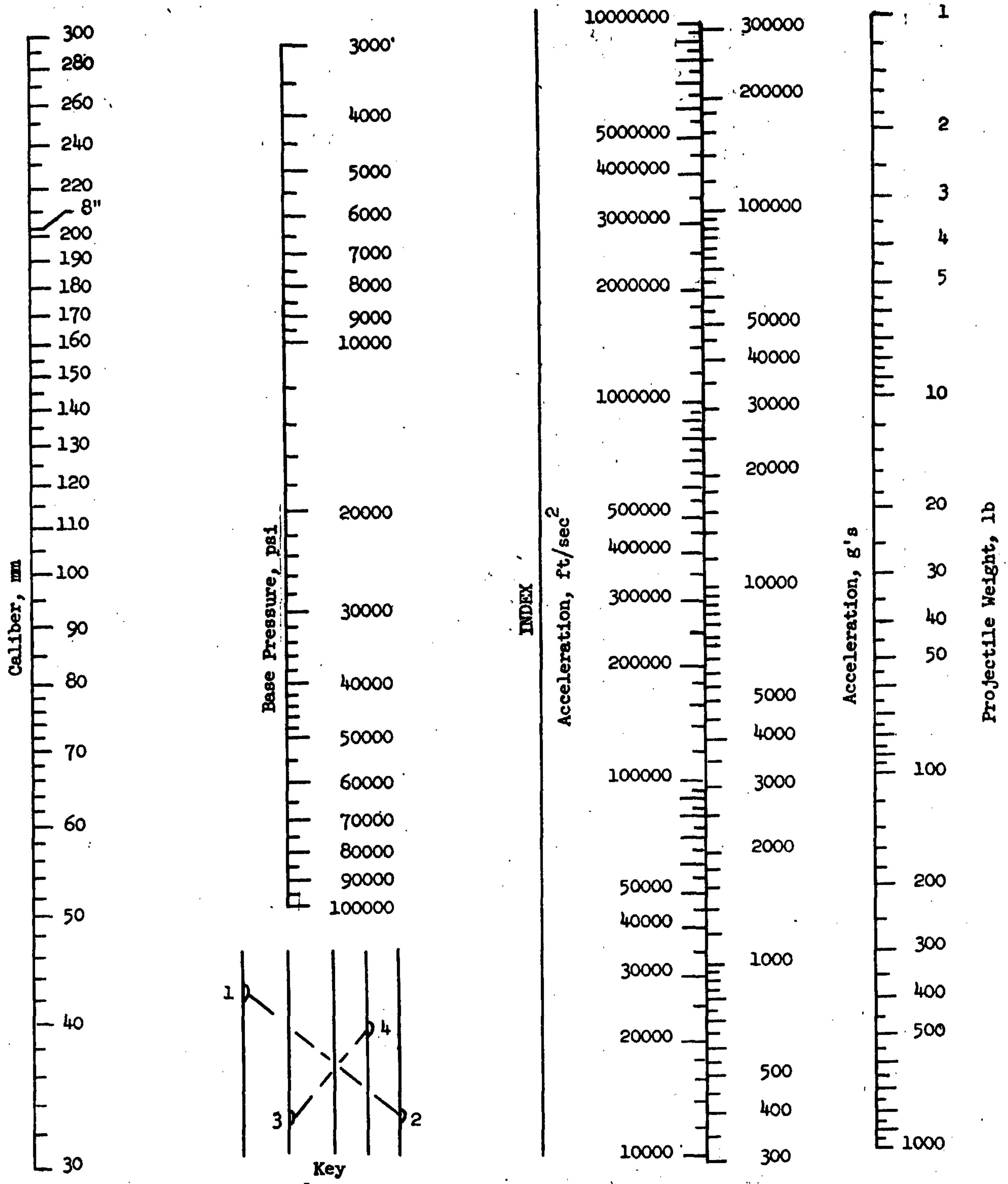

Figure 1. Projectile Acceleration for Various Weights, Calibers, and Projectile Base Pressures (Piezo Equivalent Pressures).

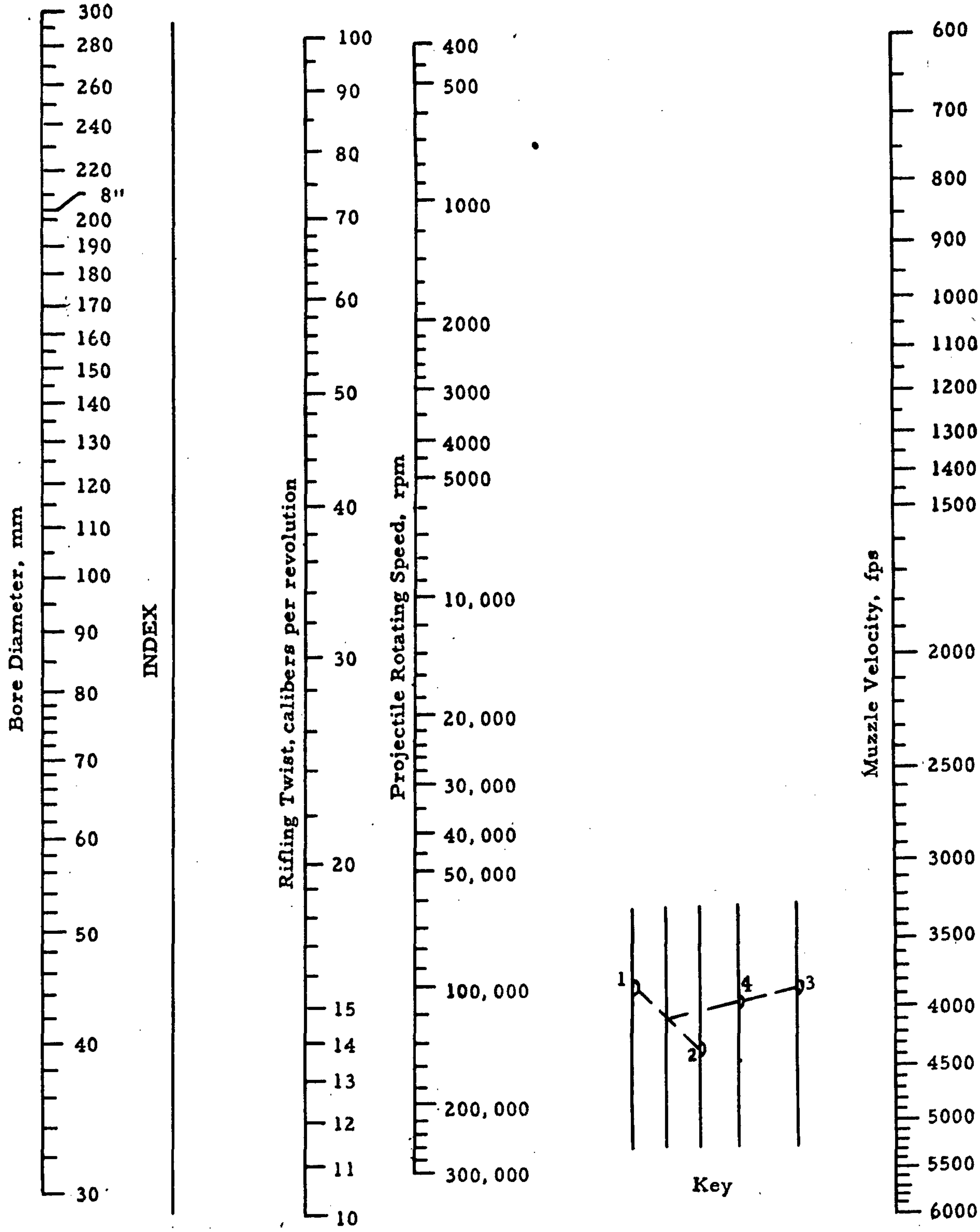

Figure 2. Projectile Rotating Speed for Various Calibers, Rifling Twists, and Muzzle Velocities.

Test results of similar fuzes and fuze components are studied to determine the extent to which these results may add to confidence in the safety of the fuze.

b. Review of Prior Testing - MIL-STD-331 required that a number of laboratory and field tests be conducted on fuzes. During these test, the fuze is not always assembled to its intended projectile (e.g., during drop, vibration, jolt, jumble and other tests). The laboratory tests are normally conducted by the developing agency who should provide information on satisfactory performance of the fuzes. Any tests not conducted by the developer should be performed during the ET. Laboratory safety tests of projectile fuzes in MIL-STD-331 are designated by Tests 101 through 115, field test data from Tests 207, 208, and 210 are also sometimes available.

In additiom to the tests of MIL-STD-331, all field data from engineer design tests (EDT) and other tests are considered in evaluating the safety of the item.

c. Safety Statement - AMC Regulation 385-12 requires the submission of a Safety Statement from the developer prior to the commencement of the ET. Review of the Safety Statement is mandatory in conncection with the design review prescribed in a, above.

6.2.1.2 Radio Freqency Radiation Hazard Test

For fuzes containing electronic components, the possibility exists that electromagnetic radiation may initiate the fuze. To assure that this is not true of the fuze under investigation, conduct the test for radio-frequency radiation initiation in accordance with the procedures outlined in MTP 3-2-615.

6.2.1.3 Exposure and Firing Tests

The most extensive safety tests are conducted during the ET with the fuze assembled to the round. The same lot of fuzes intended for the service test (ST) are used. In this way the safety release recommendation is applicable to the ST quantities. The conditions of exposure and firing for fuzes are the same as those for projectiles as described in MTP 4-2-504. Following are the minimum quantities required by MTP 4-2-504 for safety testing:

Metal parts checkout	10
Storage	75
Vibration (at extreme temperatures)	75
Sequential rough handling (at extreme temperatures)	50
Worn tube effect (if applicable)	100

NOTE: The above sample sizes are for a fuze used with a specific projectile in a specific weapon system. When a fuze is designed to be used in many systems, the quantities will be increased based on engineering judgment. The economy involved may require the elimination of testing with similar systems that would produce no differences in the effect on safety.

a. Conduct the arming distance tests of MTP 4-2-806 during the initial firing to the extent necessary to validate EDT data.

b. Conduct firing as described in MTP 4-2-504.

c. Record time and distance of fuze functioning and metal parts separation data for the test item.

6.2.2 Supplementary Environmental and Shock Tests

The environmental and shock tests of the safety evaluation will be supplemented by additional tests. From the tests below, the test director will select those that he deems necessary considering QMR or SDR requirements, product improvement plan potential use, and prior testing on the same or similar items. He will normally expose some of the test items to sequences of extreme environments which the materiel could encounter during its life. Appendix A of MTP 4-2-015 provides a general approach to sequential testing. These environments may include those listed below. One sequence would assume that the item will be sent to the arctic, another that the item will be sent to the tropics, and another that it will be sent to the desert. After each exposure all items are examined and a representative sample test-fired. The remainder are sent through the next environments of the sequence.

a. High and Low Operating Temperatures - Fuzes are almost always required to perform at the extreme temperatures. Satisfactory performance of the fuzes at extreme temperatures following the vibration and rough handling exposures of the safety evaluation (paragraph 6.2.1.3) will constitute a suitable extreme temperature test. Additional high and low operating temperature tests will be required only if failures occurred during the vibration or rough handling test. High temperature will normally be 145°F; low temperature will be as specified in AR 70-38, i.e., -35°F for intermediate cold, -50F for cold, or -70°F for extreme cold conditions, (these temperatures may be changed by the QMR, SDR, technical characteristics or product improvement plan). Record effect of additional high and low operating temperature tests on the test item.

b. Solar Radiation - This test is primarily for heat effects. The test items are exposed to the intermediate solar radiation conditions of AR 70-38, in the manner prescribed in MIL-STD-810. The test is of 5 days duration and is followed by exmaination of test items and firing at the equivalent peak temperature. Conduct test as described in MTP 4-2-826.

c. Salt Spray (Fog) - This test evaluates the corrosive effect of an ocean environment. Conduct the test in accordance with Method 509, MIL-STD-810.

d. Fungus Resistance - Conduct the test as described in MTP 4-2-818.

e. High Humidity - Conduct humidity test as described in MTP 4-2-820.

f. Water Immersion - The test items, conditioned at 113°F, are immersed in water at 64°F and left for 2 hours under 3 feet of water. Conduct the test in accordance with Method 512, MIL-STD-810.

g. Sand and Dust - Sand and dust tests are conducted in accordance with MTP 4-2-819.

h. Rain and Freezing Rain - The water immersion test is usually adequate to replace rain, but the freezing rain test should be conducted in accordance with the applicable section of MTP 2-2-815.

i. Temperature Shock - This test is conducted in accordance with MIL-STD-810, Method 503, except that the high temperature will be 155°F - the high storage temperature of AR 70-38. The low temperature will be -65°F, and the maximum time for transfer between chambers will be 30 seconds.

j. Air Transportability - The test item is placed in an altitude chamber. The pressure is reduced to simulate a 50,000-foot altitude and the temperature reduced to -65°F. These conditions are held for 2 hours, at the end of which ambient conditions are restored as quickly as facilities permit. Record the effect of reduced pressure and temperature on the test item.

k. Air Delivery - Test items packaged for airdrop are tested in accordance with MTP 4-2-509.

l. Jolt and Jumble - Jolt and jumble tests are normally used as an overtest of unpackaged fuzes. If not already conducted by the design agency, these tests are conducted according to MTP 4-2-602. Test items need not be able to function properly after testing but must be safe for handling and firing.

6.2.3 Functioning and Operational Tests

Fuzes designed to function by impact, time, or proximity will undergo appropriate conditioning, dynamic firing, and other tests to determine whether they operate and function according to design requirements under all environments specified. Guidance for number of samples, test procedures, and analysis of test results is contained in the appropriate MTP's.

The smaple size and test plan for determining range accuracy (MTP 3-1-004) will be coordinated with personnel responsible for firing table data. Functioning reliability will be computed with enough samples to provide the reliability at the confidence intervals necessary to determine compliance with the specifications (MTP 3-1-002). Data from the safety evaluation (paragraph 6.2.1) may be used as applicable to increase sample size for reliability considerations.

The following tests will be conducted when applicable:

6.2.3.1 Impact Fuzes

a. Impact Sensitivity - Impact sensitivity is determined by firing against targets offering a varying degree of orientation and resistance to the fuzes. Many fuzes are designed to be activated by targets with little resistance. They are not, however, to be prematurely activated by conditions, natural or induced, thay may be encountered in the flight of the fuze to the target. Conduct test as described in MTP 4-2-806.

b. Terminal Effects - These effects are determined in conjunction with tests of the fuzed projectile. The important characteristics in these tests are target or range dispersion, lethal effects, and reliability. Conduct testing in accordance with appliacable sections of the following MTP's:

1) MTP 4-2-501, Projectiles.
2) MTP 4-2-807, Fuze Functioning Time - Superquick Fuzes.
3) MTP 4-2-809, High Elevation (Vertical) Firing Techniques for Recovery.
4) MTP 4-2-829, Vertical Target Accuracy and Dispersion.

c. Extreme Conditions - Safety and performance of a fuze under extreme environments, including transportation and handling, are determined by tests specified in paragraphs 6.2.1 and 6.2.2.

d. Arming Tests - Fuzes are usually designed to be boresafe by inclusion of a delay arming feature in the fuze (safety adapter or booster assembly). Test procedures to determine the safe arming and nonarming distances are based on a statistical procedure for varying the target distances (MTP's 3-1-002, 4-2-806). Engineering tests may consist simply of verifying the positive arming and nonarming distances established during EDT.

6.2.3.2 Time Fuzes

a. Impact Sensitivity - (Same as for impact fuzes, paragraph 6.2.3.1a, above).

b. Time to Burst and Functioning reliability - Timing of the interval between launching and functioning in flight is required. This is accomplished be means of fuze chronographs backed up by stop watches, by telemetry methods when feasible, or by modifying the fuze to emit signals. Test firings will cover a combination of variables to include the following:

1) Weapons: Of the weapons that will employ the test fuze in their projectiles, those weapons producing the maximum and minimum interior ballistic values must be used in the test, plus others that may be desirable.
2) Charge zones: Minimum and maximum charge zones for each weapon will be used.
3) Fuze settings: Three fuze settings are usually desirable - near maximum, near minimum, and intermediate, though some test at absolute maximum and absolute minimum may be desirable.

4) Test temperatures: Tests at -50°F and 145°F should provide adequate coverage.

The exact number of rounds to fire under each condition will depend upon the reliability requirements of the SDR or QMR, and the amount of usable data acquired from other portions of the fuze test. As a rule, under one combination of conditions, no less than 10 rounds are fired. Conduct test as described in applicable sections of MTP's 2-1-004, 3-2-825, 4-2-807, and 4-2-808.

c. Extreme Conditions - Same as for impact fuzes, paragraph 6.2.3.1c.

d. Arming Tests - Same as for impact fuzes, paragraph 6.2.3.1d.

6.2.3.3 Proximity Fuzes

a. Arming Tests - The arming devices for proximity fuzes are usually tested as separate units in special carriers that detonate to give signals for recording arming time or distance. This is called functioning on arming. The use of telemetry (MTP 2-1-004) may also be desirable for certain types of fuzes. Conduct test as described in applicable sections of MTP's 3-2-615, 3-2-825, and 6-2-508.

b. Functioning Location and Reliability - Points of impact or burst are located with visual or photographic equipment depending upon the nature of the test. Variables to evaluate are weapons, ranges, zone charges, and temperatures (-50°F and 145°F). Rounds to fire under a set of conditions are dependent upon the reliability requirements of the QMR or SDR and upon other usable data available. Conduct test as described in applicable sections of MTP's 3-2-825 and 4-2-808.

c. Extremem Condtions - The same as for impact fuzes, paragraph 6.2.3.1c.

d. Electronic Counter-Countermeasure Investigation - Determine applicable electronic counter-countermeasure techniques as described in MTP 6-2-508.

e. Vertical Firing for Recovery - Proximity fuze components such as oscillators, amplifier sections, and batteries may be subjected to controlled setback loads by mounting within special hollow projectiles fitted with false nose cones and fired vertically for recovery and study. Conduct test as described in MTP 4-2-809.

6.3 TEST DATA

Record test data in accordance with paragraphs 6.1 and 6.2 and the appropriate referenced MTP's.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Safety Evaluation

An evaluation against the safety criteria of paragraph 6.2.1 will be made and a safety release recommendation prepared (USATECOM Regulation 385-6).

6.4.2 Supplementary Environmental and Shock Tests

Data will be prepared according to the applicable test reference document. If there is not specific data requirement or guidance, the test director will present the test data in the most comprehensive form for the particular test.

6.4.3 Functioning and Operational Tests

Data computed according to MTP 3-1-002 should be supported by appropriate tables and graphs.

APPENDIX A

IMPACT, TIME, AND PROXIMITY FUZES

1. IMPACT FUZE

Impact fuzes are usually attached to either the base or nose of the projectile and referred to as base detonating (BD) or point detonating (PD) fuzes, respectively, or they may be attached in part to both ends of the projectile and referred to as point initiating, base detonating (PIBD) fuzes. They contain a device to activate functioning as a result of projectile impact against a target. BD impact fuzes are usually employed in direct fire against "hard" targets, whereas PD fuzes are employed in indirect fire against "soft" targets. An impact fuze may be either delay, nondelay, or superquick, depending upon the time interval from target contact to completion of its function.

2. TIME FUZE

Time fuzes are usually attached to the nose end of a projectile and contain a device, mechanical (MT) or electrical (ET), activated as a result of a predetermined time selected and fixed into the device prior to launching. They are calibrated in seconds, or, in some cases, the time scale has been converted to "range" in meters. Time fuzes are employed when projectile functioning is required throughout a range of time and sensing for activation of a device that cannot be accomplished by means of impact or proximith fuzes. Time fuzes are most widely used in indirect fire where projectile functioning is required at a considerable height above the target.

3. PROXIMITY FUZE

Proximity fuzes are usually assembled to the nose end of a projectile. They contain a device for emitting an electronic impulse at a selected or predetermined time after launching. When this impulse is reflected back to the fuze, for a distance predetermined and built into the fuze, the fuze functioning is initiated. The fuzes also usually have an impact device as a secondary initiating feature. These fuzes are used primarily for indirect fire where projectile functioning is required near the target and greater precision in distance from the target is required than is offered by the present preset time fuze. The proximity fuze may have a requirement for use against aircraft and may also contain a self-destruct feature.

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13. ABSTRACT

This Engineering Test Procedure describes test methods and techniques for evaluation of the technical functions and characteristics of Ammunition Fuzes for artillery, mortar, and recoilless rifle projectiles, as related to the criteria established in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), or other applicable documents pertaining to fuze requirements and design.

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Test Procedures						
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